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NATURE AND CAUSE OF DECAY IN BUILDING TIMBERS

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NATURE AND CAUSE OF DECAY IN BUILDING TIMBERS

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Omitting from consideration the questions of fire, flood, and tornado, decay is the largest single cause of destruction in lumber and timber used for permanent construction. While the elements of risk with the former, more spectacular, agencies have been carefully analyzed over a long period of years and their economic importance reflected in insurance rates, no public or official cognizance, other than that sometimes assumed in regulatory functions, has been taken of the incidence of rot in buildings and the hazard arising from its development. Our building codes provide uniform regulations covering wiring, plumbing, and protection against fire and collapse, but very few of them have anything to say about the prevention of decay. This is all left to individual judgment, which varies as widely as the limits of our country and, as evidenced by the heavy losses resulting, is often lacking in the technical knowledge necessary for successful decay control.

Decay prevention hinges upon the practical recognition of a very few essential facts which, if translated into specications, will largely insure immunity from rot. Application of these facts requires no revolutionary changes in present practice, often merely minor corrections here and there. I do not hesitate to say that if full advantage were taken of the technical information at present available, decay could practically be eliminated as an important factor in the life of buildings. Theory and observation alike prove that buildings can be erected in any part of the country which, with only minor external repairs occasioned by exposure to weather, will give service until they become obsolete.

Considering the country in general, it can be stated that aside from buildings of "wet occupancy" such as textile mills and paper and pulp mills, in which high atmospheric humidities are maintained either purposely or as a result of manufacturing processes, the greater losses from decay occur in the southern states from eastern Texas to the Atlantic, and in the Pacific Northwest. In these regions the temperature and moisture conditions are particularly favorable for the growth of wood-destroying fungi, and more especially for one of the widely distributed dry-rot organisms, which has there become almost an epidemic.

What Causes Decay?

Decay is caused by the development within the fibers or cells of the wood of what we term wood-destroying fungi. These are often evident on the surface of infected or decayed wood as cottony growths or as papery sheets (fig. 1), which may also fill the cracks of the decayed material. Under the microscope the component parts resemble cotton threads. These threads (collectively termed mycelium) penetrate the wood (fig. 2) and dissolve its substance by means of ferments.

To propagate itself, a wood-destroying fungus often develops a fruiting body which in turn forms spores (fig. 3). The familiar brackets, conchs, mushrooms, toadstools, etc., which form on the exposed surfaces of infected wood are fruiting bodies, and the spores, in almost limitless number, are produced on some part of their surface. Fruiting bodies are often lacking on decayed building timbers but the fungus may still spread by means of the continuous growth of sheets of mycelium, or of root-like strands from one timber to another, or by the passing of the fungus threads from within the wood of a decayed piece to a sound piece in direct contact. Some fungi also produce small secondary spores on the threads and these bodies may also serve to distribute the fungus to some extent.

The spores of fungi have just the same function as seeds, but being infinitely smaller, even much smaller than the pollen which causes such discomfort to a hay-fever victim, they are easily wafted about for long distances by air currents. Provided they have not dried out too much during their peregrinations, they will germinate and form new mycelium when they settle on susceptible timber in a moist condition. It is believed, however, that spores are far less important in distributing fungi within buildings than they are in causing infections of timber exposed to the weather.

Since fungi are plants, a rough analogy can be drawn between them and the higher plant forms with which we are all familiar. The threads, or mycelium, can then be likened to the roots, the fruiting bodies to the plant above ground, and the spores to seeds.

What Conditions Influence Decay?

The conditions that favor decay are necessarily those which favor the rapid development of wood-destroying

fungi. We therefore prevent decay by making the environment so unfavorable to the growth of the fungi that they cannot gain a foothold. For practical purposes only two factors need discussion, namely, moisture and temperature.

Moisture.--So far as we know, decay-producing fungi will not attack wood to any appreciable extent when the contained moisture is below the fiber saturation point, which varies from 20 to 30 per cent of the oven-dry weight of the wood according to the species of timber; nor will they decay wood completely saturated with water. Between these limits wood is subject to varying degrees of attack, the rate of decay apparently decreasing as we approach the limits. In a recent study of the decay of hemlock pulp logs during a storage period of approximately 1-1/2 years, 25 per cent of the cross-sectional area of two of the logs was found to have become considerably decayed while drying from a green condition to 130 per cent moisture, while 70 per cent of the cross section of three others became decayed while drying to 50 per cent.

According to Department of Agriculture bulletin No. 556[1], the moisture content of green timber varies widely. A few of the species, including a number used largely for structural purposes, may be listed:

	Per cent moisture
White ash	40
Sugar maple..................	60
Yellow birch.................	68
White oak....................	68
Red gum......................	81
White elm....................	88
Black willow.................	138
Douglas fir..................	36
White spruce.................	46
Longleaf pine................	47
Western larch................	58
Loblolly pine................	70
Eastern hemlock..............	105
Balsam fir...................	117

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[1] Newlin, J. A. and Wilson, T. R. C. "Mechanical Properties of woods grown in the United States." 1917. The figures here given are averages for a number of trees; wide variations for individual trees may be expected. For example, the average of different samples taken from a single tree of eastern hemlock was about 160 per cent, while the average for a number of trees of this species was 105 per cent.

Most of these species will decay, at least to a slight extent, in essentially a green condition, which argues for the tolerance of wood-destroying fungi to varying degrees of moisture, even when at a point not far removed from fiber saturation.

Unfortunately, accurate experimental information on the moisture content most favorable to decay is lacking, but from the available data and the few observations at hand it would appear that this varies for the different kinds of wood, and possibly for pieces of the same kind of wood having a different specific gravity, as well as with the different fungi. The most that we can expect, then, is that only thoroughly air-seasoned or kiln-dried timber will yield satisfactory results when used in places where it is not freely exposed to rapid drying. But as a matter of fact, initial dryness of the timber gives no immunity if the surroundings are themselves damp and stagnant.

Temperature.--The temperature conditions requisite for fungus development are satisfactorily met, for at least a portion of the year, in all parts of the United States. The optimum for many species lies between 75 and 85° F., while for a few it may run as low as 68 to 70° and as high as 96 or 97°. Of a considerable number of fungi tested only one survived 115° F. These data apply to growing fungi freely exposed in incubators to uniform and constant temperatures. The same species growing deep in large timbers would not be arrested in growth until the temperature of the interior of the wood reached the inhibiting or killing point. It has been determined by experiment[1], however, that the kiln-drying schedules recommended by the Forest Products Laboratory completely sterilize wood up to four inches in thickness which has become infected or decayed by many species of fungi.

The effect of very low temperatures is to retard or stop the growth of fungi. The severest winters, however, do no more than render them temporarily dormant; some readily withstand the temperature of liquid air (-220° F.). In only one instance have I seen wood-destroying fungi active near the freezing point. This was in a cold storage plant maintained at 33 to 34°. The exposed low-grade pine joists here gave less than two years' service.

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[1] Hubert, E.E., "Effect of Kiln Drying, Steaming, and Air Seasoning on Certain Fungi in Wood." U. S. Dept. Agr. Bull. No. 1262, Aug. 1924.

As has been stated, decay prevention hinges on a few essential facts, the regulation of moisture being a prime necessity. While the regulation of temperature offers few permanent practical possibilities in the way of killing fungi present in the wood, effective use can be made of artificial heat, or even natural atmospheric temperatures, in reducing the moisture in imperfectly dried stock. I refer here to instances where fully seasoned stock is difficult to obtain, or where the stock has been subjected to rains just before use. Here it becomes imperative to reduce the moisture content before any of the framing timbers are covered by finishing materials. Two cases will illustrate this principle.

In a semi-mill constructed building in Chicago investigated several years ago[1], the partially seasoned low-grade pine timbers had been fully enclosed with plaster board (fig. 4) while in a moist condition. In approximately two years the floors began to sag and a few of the girders and posts in the basement failed (fig. 5). A thorough examination then indicated the necessity of extensive repairs throughout the six stories of the structure as a direct result of decay in the undried structural members.

The second illustration is that of a frame residence in which the hardwood siding on one side decayed and required replacement after two years and four months, while on the other three sides it remained sound. According to report the material on the defective side was laid during wet weather, probably over a damp back surface of building paper; on the other three sides the materials appear to have dried out before the siding was laid. While this is a very unusual case, it shows what damage enclosed moisture may cause.

Had the Chicago building been heated for a few weeks to complete the seasoning of the timber before covering, in all probability no trouble would have developed. Likewise the use of dry siding and a day of sunshine would have protected the residence.

<u>What is Meant by Dry Rot</u>?

A great deal is heard about "dry rot." Unfortunately, this designation is often used to cover any kind of

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[1]Humphrey, C.J., "Timber Decay and Its Growing Importance to the Engineer and Architect." Jour. West. Soc. Eng. 22:61-73, 1917; Ry. Age Gazette 61; 1085-1087, 1916; Ry. Maint. Eng. 13:24-26, 1917; Sci. Am. Suppl. 83, No. 2159: 314-315, 1917.

decay, for most of the advanced decay in building timbers is brittle and crumbly when dried out. The term therefore loses its special force when it means any kind of rot. Dry rot[1] in its proper meaning is a thing to create special consternation, something ultra in destructiveness, a plague to be stamped out in its early stages before the whole structure comes within the clutches of its tentacles.

The distinction between dry rot and other kinds of rot does not lie in the appearance of the decayed wood, but rather in the highly specialized development of the fungi concerned, for they all produce water-conducting strands or growths (fig. 6) which connect with wet or moist soil and carry water for long distances, sometimes 20 to 30 feet, upward into a building, a most efficient conduit system. Hence it makes no difference how dry the timbers may be, once the dry rot strands reach them, they are soon moistened sufficiently for rapid decay, and eventually may become saturated and dripping.

The water conducting growths (fig. 7) of the principal dry rot fungus of the South and Pacific Northwest are dirty whitish in color and often resemble the fluted irregular stem of a grape vine. They may grow to several inches in diameter and sometimes take root in the soil like a tree. Those of other dry rot fungi resemble shoestrings and are often brown to brownish-black.

The dry rot fungi are all rapid growers and seem to be prevalent in soil in the moister parts of the country. It is therefore highly unsafe, practically an invitation to disaster, to allow any cellar, foundation (fig. 8) or first floor timbers (fig. 9 and 10) to come in contact with the soil, or very close to it, unless they have been thoroughly impregnated with a wood preservative.

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1 Humphrey, C. J., "The Destruction by the Fungus Poria incrassata of Coniferous Timber in Storage and when used in the Construction of Buildings." Sou. Lumb. Jour. 49, 36, 37. 49-53, 55, 1923; Am. Wood Pres. Proceed. 19, 188-201, 1923; Ry. Purch. & Stores, Mar. and Apr. 1923; West Coast Lumberman 43, 24-25, 42-44, Feb. 15, 1923; Mycologia 15, 258-277, 1923.

Humphrey, C.J. and Miles, L.E., "Dry Rot in Buildings and Stored Construction Materials and How to Combat it." Ala. Polytech. Institute Circ. 78, 1925.

Edgerton, C.W., "Dry Rot in Buildings and Building Material." La. Agr. Exp. Sta. Bull. 190, Apr. 1924.

Sufficient records are available to indicate that preventable dry rot is costing the country many millions of dollars yearly. In Alabama alone the cases which have come to my attention in some fifteen cities and towns, and upon which approximate repair costs are known, have caused expenditures of $200,000, and it is estimated that this is not more than a twentieth of the total loss to the state.

The menace of dry rot appears the greater when it is considered that the fungus has invaded stored stocks in lumber sheds (fig. 11 and 12) as well as various building materials in warehouses. Close inspection will be required to prevent the distribution of any material so infected, with its attendant hazard to the contractor or builder who may inadvertently use it (fig. 13).

Although the fundamental conditions for decay are the same everywhere, the rot problem in buildings of dry occupancy is different from that in structures of wet occupancy, and the two phases will therefore be discussed separately.

Decay in Buildings of Dry Occupancy

In the Rocky Mountain states and the northern states eastward, as well as in the arid Southwest, severe cases of rot in residences and buildings of ordinary construction occur only sporadically. Part of this decay is dry rot caused principally by species of Merulius, the remainder consisting of infections by a comparatively few other fungi. It is not uncommon for exterior trim or porch timbers of residences to decay slowly, but this condition can usually be corrected by minor repairs. My present residence in Madison is perhaps thirty years old, and nothing more than a few window sills and the shingles have required replacement, as far as I know. An old store building, said to antedate the Civil War, was recently torn down in this city and the timbers were found to be almost sound throughout. Here cedar shingles frequently give 25 or more years of service and then fail as much from weathering and splitting as from decay.

Ordinary floors laid on or close to the ground give considerable trouble, and occasionally serious decay occurs in basement floors laid over a concrete slab which is apparently not as waterproof as the specifications prophesy.

In general, the rot problem in the drier, cooler parts of the country is not serious in residences and ordinary buildings outside of mill construction. In the North Atlantic region, characterized by a somewhat heavier rainfall, dry rot sometimes causes considerable individual loss, but it has not assumed almost epidemic proportions as it has in the South.

In mill-constructed buildings of dry occupancy decay becomes considerable at times in our larger cities, owing primarily to the injudicious use of green, or only partially seasoned timber, often non-durable in character. I have investigated a number of such cases, especially in Chicago. Laminated floors have there given particular trouble, and this, in my opinion, can be traced to the use of moist, low-grade stock, which in many cases has been floored above and ceiled below before it could dry sufficiently to prevent fungus growth. In the extreme West the situation is not different with respect to the ordinary rots. I have seen 12 by 20-inch Douglas fir timbers rotted off at the ends in about four years when closely embedded, while moist, in concrete columns (fig. 14), and frequently the same will happen to joists and girders set closely in brick walls.

While we may sometimes take long chances with construction in the North, and get by with it, we cannot be at all haphazard in what I have designated as the dry rot regions. The least slip there in keeping every foundation timber well off the fungus-infected ground, in providing ample ventilation, in removing from beneath a building every scrap of woody debris that can propagate dry rot, may spell disaster. A man may put up a fine home and perhaps two or three years afterward find the floors quivering and collapsing beneath his heel and the dry rot pipe lines laid through the walls to the second story; or possibly he may be disturbed by the falling of the doors from rotten casings, or mayhap the peace and comfort of his boudoir may be annihiliated when his couch of slumber takes a sudden list as a leg crushes through the supports. One must be wary in dry rot territory.

As we progressively analyze the rot situation in all buildings of dry occupancy, we find that each case links up with the two essential faults of construction already mentioned, namely, moisture in the timber, owing to insufficient seasoning or to subsequent absorption, and contact of the stock with fungus-infected soil.

By way of recapitulation here, the principal danger points may now be listed and certain suggestions offered.

1. Foundation or basement timber should never be placed in contact with the soil, unless the timber is impregnated with an antiseptic.

2. It is not good practice to lay wood floors over concrete slabs resting on the ground without treating the sleepers, and preferably the subfloor, with a wood preservative. An air space between the subfloor and slab is desirable if the subfloor is untreated. The same applies to floors laid over a brick base or over other material pervious to moisture and possibly to fungi. Many cases of failure from decay in improperly constructed floors are on record.

3. Laminated floors, especially, should be constructed of a good grade of air-dry stock, although it is maintained by one Chicago architect[1] that if the stock is spiked together rough from the saw, without surfacing, satisfactory results can be secured even from green material, provided it is not ceiled in.

4. One should specify and insist upon durable grades of timber with as much heartwood as possible, for mill construction purposes. The timber should be properly air seasoned when used at points where the moisture may lead to decay or where the wood cannot be seasoned rapidly in position.

5. Embedding girders or joists in brick or concrete walls or piers without ample ventilation around the enclosed ends has resulted in many failures. Metal bearing plates and corbel construction are considered good engineering practice and are much to be preferred from the standpoint of decay prevention. No trouble has been observed from the use of metal stirrups.

6. Covering, oiling, or painting timber before it is thoroughly dry will usually lead to decay. Tinned fire doors have been known to rot when a wet core was used.

7. Complete cross ventilation from all sides should be provided beneath buildings having no basements (fig. 15).

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[1] See Jour. West. Soc. Eng. 22, 77-78, Feb. 1917.

8. Scrupulous attention should be paid to the removal of all forming from concrete foundation piers or walls. Dry rot readily travels upward through any lumber or timber touching the ground.

9. All odds and ends of lumber which may have accumulated on the ground beneath the building during construction should be removed. Such debris harbors the white ant and supports the growth of dry rot, which may get a sufficient start to spread up over the masonry walls into the foundation timbers.

10. It goes without saying that constant caution should be exercised against leaks in the roof, in plumbing, and around windows and doors, and seepage through stucco, which may wet the interior timbers.

11. Last, but not least, all timber and lumber should be carefully inspected for evidence of rot. This precaution is particularly necessary on account of the increasing development of dry rot. Blue stain and most other stains are negligible defects from a strength standpoint. They do, however, sometimes indicate previous storage under conditions which may also have started decay. The early stages of decay are evidenced by a slight but noticeable softening of the wood, and often by a bleaching. In the dry rot territory the dry rot fungi should be particularly guarded against; one cannot afford to take the least chance with them.

Many builders will probably still transgress the inviolable laws of decay, some wilfully, others through force of necessity; my plea is that each one do the best he can toward safeguarding the properties for which he is responsible against invasions of wood-destroying fungi.

Decay in Buildings of Wet Occupancy

In a brief review of the rot situation in buildings of wet occupancy, the textile mills afford typical conditions for discussion. The artificial humidities, frequently up to 85 per cent, maintained in certain portions of such buildings, have frequently led to serious decay in the roofs. Roof decay[1] is brought about by water condensing

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[1] Blair, R.J., "Decay in Textile Mill Roofs." In Canad. Textile Jour., Mar. 4, 1918.
Hoxie, F.J., "Roof Construction for Factories with Excessive Moisture." In Am. Architect 115, No. 2249; 181-187, Jan. 29, 1919.

on the under side of the timbers, and the problem has demanded special engineering attention.

Many of the weave sheds are of sawtooth construction, but under the same mill conditions decay is just as likely to take place in a flat roof. The life of the roofs has been extremely variable, according to the grades of the timber used and the interior moisture and temperature conditions prevailing. All heart 3-inch southern pine roofs have lasted from 15 to 20 years in Massachusetts, but much more frequently the average roof has failed within 6 to 9 years. The use of sap pine has proved a costly proposition.

The principal decay in the roofs often occurs in the outer half or within a more or less middle plane in the 3 to 4-inch planks (fig. 16), and over the beams, at which point the rot at the contacts is severe (fig. 17). This localization of rot can perhaps be best explained by assuming a definite set of conditions in illustration. Suppose the outside air to be at 30°, the room temperature 70°, and the dew point 60°, with very little air circulation under the roof. Whenever the interior air next to the under surface cools to 60° or less, condensation (sweating) takes place and saturates the lower surface of the planks, gradually being absorbed toward the center. Fungous growth then becomes conditioned by both moisture and temperature within the piece. If lower temperatures and drier wood tend to retard rapid development on the upper face and the lower face becomes too wet to decay, rotting will take place in the interior. If the lower face does not become too wet it will also decay.

Assuming that the air circulation under the roof is sufficiently good to maintain the temperature above the dew point, that the entire temperature difference occurs through the plank with a uniform gradient, and that rotting begins at the dew point, decay will then start at a point in the plank three-quarters of the distance through from the outside, where the temperature is 60°. The rot zone thus necessarily fluctuates according to the outer and interior temperatures and the dew point. When a wide supporting beam is encountered, the rot zone is brought down into the upper central portion of the beam (fig. 18), owing to the increased thickness and insulation of the roof at that point.

The obvious protection for the beams is to make the timbers narrow enough at the plane of contact to allow them to come approximately to room temperature. A recognized engineering practice is to make the width of bearing no greater than the thickness of the roof. This can be

accomplished by chamfering off the upper corners of the beam. Ornamental moldings at the upper edges only accelerate the destruction by throwing the rot line outside the bearing, thus destroying the supporting ends (fig. 19) before the remainder of the plank is much affected.

Rot in the planks can be prevented by increasing the insulation of the roof and by a suitable distribution of the heating pipes so as to prevent moist air from condensing on the under surface. For new construction, a double roof consisting of an inner layer of durable untreated timber of a good grade and an outer layer of creosoted stock with a triple layer of mopped tarred roofing between, will be found satisfactory; the whole to be tarred and graveled in the usual manner.

If, in addition to these precautions, roof ventilators are eliminated and rain conductors passing through the rooms are insulated to prevent condensation, decay will for the most part be overcome.

Eradication of Fungous Infections

In the case of the decaying roofs just discussed, a satisfactory expedient to increase the life more than enough to warrant the cost consists in laying on the old gravel roof or over three-ply roofing a top insulation of 7/8-inch creosoted boards on 7/8-inch furring[1]. This construction is said to stop roof drip and extend the life of the old timbers.

Decay in mill-constructed buildings of dry occupancy is difficult to remedy, the obvious method being the removal of decayed members which have become unsafe. Drying the remaining timbers by the application of heat is a valuable measure wherever it is practicable. This method will not ordinarily kill the fungi, but will retard their growth and may render them practically dormant.

In some instances it appears that certain fungi may run their course in a building and then die as the timbers gradually dry out, not however before extensive damage has occurred. Before undertaking extensive repairs it is always advisable to have culture tests made from various timbers to determine whether the fungus is alive or dead.

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[1] Browne, Wendell S., "The Preservation of Decaying Wood Roofs." Mech. Engineering, Nov. 1922.

Dry rot infections require drastic treatment, and nothing short of the removal and destruction of all traces of the decay are recommended. Replacement should be made, preferably with treated stock and adjoining timbers, masonry, and soil should be sprayed with an antiseptic in an effort to reach any traces of the fungus which may have been left.

Preservative Treatment of Building Timbers

Timber which cannot be suitably safeguarded by construction practice can be rendered immune to fungus and insect attack by treatment with a preservative. Such treatment is always necessary in the case of timbers which may come in contact with the ground. It is also to be generally recommended for sleepers (screeds or nailing strips) beneath floors laid over concrete or brick in contact with the soil. If the sleepers are embedded in the concrete or in moist filling materials of any sort, their thorough treatment should not be neglected on any account. In fact, under the conditions mentioned, the treatment of sleepers should be made obligatory by incorporation in building codes.

There are two substances in general use for the treatment of timber, namely, coal tar creosote and zinc chloride. Mercuric chloride (corrosive sublimate), sodium fluoride, and several others are also used to some extent.

Coal tar creosote is a black to brownish oily, pungent substance practically insoluble in water. It is highly effective against both fungi and white ants and is repellent to other insects and animals. In closed places the vapors from freshly treated stock may prove objectionable but with subfloor timbers which are suitably ventilated no trouble will be caused. There are a number of creosote products on the market primarily designed for shingle stains. These are not recommended for the preservation of building timbers.

Zinc chloride is a colorless, water-soluble preservative. It is ordinarily used in a 2 to 5 per cent solution[1], the concentration depending upon the method of treatment employed. Where timber is subjected to moisture it may leach from the wood to a certain extent, and in such circumstances creosote is usually preferred.

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[1] Five pounds of chemical to 11-1/2 gallons of water makes a 5 per cent solution.

Mercuric chloride (corrosive sublimate) has been used for many years in treating timber, with very good results. It has not come into general use in the United States, however, on account of two serious drawbacks. It attacks metals, and it is poisonous to handle. Therefore, it cannot be put in metal vats, and workmen handling it should use rubber gloves and carefully guard their operations. It is generally used in a 1 per cent water solution.

Sodium fluoride is a colorless preservative of comparatively recent introduction. It is highly efficient and fairly cheap. It is soluble in water and is applied in a 3-1/2 to 4 per cent solution. It is safe to handle and is one of the best substances for treating interior finish which must later be varnished or painted.

Methods of Applying Wood Preservatives

There are four standard methods of applying wood preservatives:

In pressure treatments the preservative is forced into the wood under pressure in closed cylinders. This method is the best, having the advantages of speed in operation and a relatively deep penetration. There are many wood preserving plants which treat with creosote and zinc chloride by the pressure process, but unfortunately small special orders are not always readily filled.

The hot and cold bath treatment is next in general effectiveness to the pressure treatment. With sap pine practically as good protection can be secured by this method as by pressure, especially if the timber is dry. The treatment consists in heating the wood in an open tank of the preservative for several hours and then quickly submerging it in cold preservative or leaving it to cool in the original bath. Heating the timber in the preservative, without subsequent cooling therein, is not usually sufficient. In heating, the object in view is to expand and drive out part of the air and moisture in the wood. Upon cooling, the rarefied air that is left contracts and produces a suction which draws the preservative into the timber.

When coal tar creosote is used, the temperature of the hot bath should be maintained at 190 to 200° F.; higher temperatures will cause increased losses by evaporation. When water solutions are used, they should be kept near the boiling point and the tank covered; it will be necessary to add water from time to time to replace that which evaporates.

For creosote, a metal tank or a wood tank lined with metal should be used, as an unlined wood tank will leak. For the water-soluble preservatives (except mercuric chloride which corrodes metal), either wood or metal can be used. Metal tanks allow of heating by means of a fire beneath; wood tanks require the installation of heating coils.

The period of time allowed for the hot and cold baths must be governed by the ease with which the timber takes the treatment. Sap pine and other woods moderately easy to treat should not require a hot bath of more than two or three hours and a cold bath of like duration.

After treatment creosoted timbers should be allowed to surface-dry, while those treated with water solutions should be allowed to season before use.

The <u>steeping process</u> is a step lower than the hot and cold bath in effectiveness. It can be used where large amounts of preservative are unnecessary, or where time is not an important consideration. The well-seasoned timber is merely soaked in a cold solution of a water-soluble salt. Mercuric chloride is the preservative which has most generally been used, in which case the process is known as "Kyanizing"; zinc chloride and sodium fluoride are just as well adapted, however. The duration of the steeping treatment is determined by the size of the timber, the wood being allowed to soak one day for each inch in thickness, plus one day more for good measure. Since no heating is employed, the penetration of the preservative will be comparatively slight, and as a protection against decay this method will naturally be less effective in moist situations than others giving deeper penetrations.

In building construction the steeping process seems particularly adapted to the thinner stock, when used in places where only a moderate degree of protection is desired.

The simplest of all the treatments consists in <u>dipping the dry timber in hot creosote</u> for ten to fifteen minutes, or applying the oil with a brush or spray. Such treatments do little more than sterilize the surface, but for buildings in process of repair the brush or spray method is of course the only one feasible for the timbers left in position adjoining infected areas. The brush or spray can also be used to advantage in treating the masonry and soil beneath infected buildings.

MR. WOOLSON: I have been exceedingly interested in the very splendid exhibition we have had of the various kinds of dry rot and the demonstrations which we have had on

the screen, and I am very much surprised that Mr. Humphrey has left out an example, or at least I didn't see any example of a very common form of dry rot which has come to be very serious in connection with reenforced concrete work, that is, the placing of wooden floors over concrete floors.

We find in New York City that some very large losses have been created by having to renew wooden floors that have been placed over concrete floors. The first example of that which came to my attention was in a floor of the very handsome monumental library at Columbia University, where they put down 4 by 4-inch strips on the concrete about three months after the concrete floor was laid; then placed rough flooring, waterproof paper, and a fine 2-inch quarter-grained oak surface. It lasted, I think, about six years and then the floor began to deteriorate. They took it out and found that the screeds were all gone. You could take them up with your fingers, and a good deal of the top surface flooring was gone.

Apropos of the second last picture that was shown of protecting dwelling house structural members by a brush coating of creosote, I will relate a little experience that happened to one of the well-known citizens of the country, one of the Vanderbilts in New York, quite a number of years ago. They built one of their handsome residences on Fifth Avenue. Through the advice of their architect, they creosoted the timber underneath one of the floors. In the fall the family moved in. A few weeks after the heat was started, the family decided to move out. The floor was taken up. I believe it cost $25,000 for that floor. Fortunately money was no particular object to that particular family; nevertheless, you can't always use creosoted lumber. That is, you can use it, but it is not desirable to use it.

I have had two or three rather remarkable experiences with what dry rot (or at least I call them all dry rot; I learned today that probably one of them was not dry rot) will do.

About fifteen years ago I was called by one of the fire chiefs in New York to go and examine a building that had suddenly failed after there had been a fire in it, and they could find no cause of failure. They sent some insurance inspectors there and other inspectors, but nobody knew what was the matter, and yet there was apparently some reason for failure.

On investigation, I found that on the second floor they had heavy machinery, (it was a paper factory; at least they did some paper process work in it) therefore it was

supported by heavy wooden posts. The history of the fire was that it occurred in the early evening. It burned some of the flooring, some of the contents, nothing very serious. They put out the fire; the men went away. Nothing serious really had happened. They left a man on the job who fortunately stayed out of the building and an hour or so afterward, without any warning, the whole building came down. The four-story building collapsed into the basement.

The firemen, realizing that this timber was very heavy and had not burned through, were wondering what was the matter. After careful investigation, I discovered that these posts (by the way, this was rather remarkable) were mostly white oak, fourteen inches square, a few yellow pine, but mostly white oak, and they were capped there with cast-iron caps. Upon investigation, I found that they had what I called dry rot. Mr. Plummer, I suppose, would call it wet rot. This at the time had gone down through the middle of the posts for fifteen or eighteen inches. The outside had given no signs of failure, and the fire had gone through this little shell that was left on the outside. In the course of an hour or so it burned what little remaining wood was left in the columns. They gave way and the result was that the building came down. I counted some twenty or more, I believe, of those columns that were rotted almost through with that half an inch of wood left on the outside. It was quite a remarkable example and showed the danger that those people were living in without fire. The fire was really a blessing to them, because there were a large number of people working in that building, and it might have occurred any time in the near future.

The other day I was called in to ascertain the cause of failure where an old storage warehouse had suddenly collapsed, or a portion of it had collapsed. In this case, I found that the floor which collapsed had wooden posts about 12 inches square of yellow pine. The floor and ceiling were covered with sheet metal. The building had apparently been erected fourteen years, and the original cause of failure was one of the posts which had rotted entirely underneath the sheet metal. This was a case of pure dry rot, because it had all the characteristics of dry rot. Other posts were not so badly rotted, but still there were enough of them so there was considerable area that collapsed.

I know of one or two other cases, but I don't know as they are of enough importance to pay particular attention to, except to bring out this point, and I would like to get Mr. Humphrey's viewpoint on it. In reporting upon that Gledhill Paper Factory fire, drawing upon

information furnished by the early specifications for mill construction as gotten out by Mr. Atkinson, advocating the boring at the top and cross boring part way down, I suggested the difficulty would probably have been avoided by thus boring the post. I was promptly called to account and told that this would probably have hurried it along and the disaster would have occurred earlier.

MR. HUMPHREY: There should be no reflection on Mr. Atkinson in that connection. He is not the only one who believed that boring favors the passage of fungi through the building. Some of the Chicago engineers support that view also. I have not had any personal experience.

MR. WOOLSON: I want to ask another question. We have to face a condition in reference to concrete floors, putting the wooden flooring on top. We can't wait until that floor is entirely dry before the wooden flooring is put on, and usually the screeds or clinkers are embedded in a loose fill, sometimes a wet concrete fill, which introduces moisture to start with, and there is where you find in about six or seven years the difficulty comes in. Those floors are deteriorating rapidly. I would like to ask Mr. Humphrey if he thinks it would correct the difficulty to have that timber treated with a brush coat of zinc chloride solution, also if a brush coat on the top of the column in cast-iron caps or steel caps would correct the difficulty, or what other method can be employed which will reduce that very serious difficulty of not only introducing moisture but probably using moist timber, because we can't get dry timber even if we are careful when it is delivered on the job. It is usually wet before it is put in.

I mean where the cap comes down two or three inches around the edge and the whole end of that column is encased by the cap. If it is large timber, it never is dry. Would the brushing of that with chloride of zinc or some other solution probably lessen that difficulty sufficiently to make it a fairly safe proposition?

MR. HUMPHREY: To answer your question about the brush treating of screeds with zinc chloride, I hardly think that would be effective. You can't get enough treatment by brushing it on the surface to do much good.

In connection with the end of your posts, you perhaps could get considerable penetration and you would get considerable benefit from the application. I believe creosote would be better if you can stand the odor.

In speaking of creosote under floors in residences, while I have not observed any cases where it has been used in a strictly enclosed type of construction, I have seen a number of other cases where it has been used with no trouble. I think your suggestion is a good one. We don't have to use creosote. We have sodium fluoride and zinc chloride, which are effective. If the timber is sufficiently pregnable so you can put enough of the stuff in you will protect the wood.

We have plenty of different substances if anybody wants to use wood preservatives, but the screeds should be impregnated deeply, and I believe that some of the floors should also be treated thoroughly.

MR. WOOLSON: Could that be done at any economical price without an expert to apply it in covering concrete floors?

MR. HUMPHREY: Yes, but the great trouble with the water solubles is that you have to dry the material after it is treated.

MR. WOOLSON: It goes in wet, because they encase it in concrete, so it is bound to be wet.

MR. HUMPHREY: Very often the textile mills have applied their own treatment by building vats and soaking the timber in the hot solution for a sufficient period and cooling it. That gives you a treatment for ordinary construction. We have a wood preservative man who may want to enter the discussion. I suggest Mr. Hunt tell us something on the subject.

MR. WOOLSON: You can see, I think, Professor Humphrey, that would not be a practical proposition where buildings are going up here and there. A man could not put in a treatment plant to do that very well for one building.

MR. HUMPHREY: The tank doesn't cost very much. A wooden or steel tank of small dimensions would be satisfactory, but it is the trouble and the inexperienced workmen which are the greatest drawbacks. I personally feel that some of our lumber yards could treat stock on order in open tanks, hot and cold bath, and I would like to see more of that done.

I raised a point in regard to the fire hazard. It is well known that decayed timber is a distinct fire hazard. It will set on fire from a spark very quickly, and once it is on fire it burns very readily. It is a point I didn't mention, because there were so many things to say. Mr. Hoxie brought that out very well in his little pamphlet on dry rot.

You mentioned rotting of floors and screeds. I have cases in New York City where apartment house floors have rotted out. It is a big problem which I believe must be met by the preservative people. I have been recommending preservative treatment in such cases. I do not believe complete waterproofing of the concrete would stop decay, even if dry timber were used. It is a question upon which we need some thorough observation.

MR. FRED W. LUMIS (Building Commissioner, Springfield, Mass.): I would like to relate a personal experience with dry rot. About ten years ago I took a great deal of pleasure and pride in building up a preserve closet myself. I used some flooring that was left. It was hard pine and kiln dried. I noticed about two years after it had been built dry rot had set in, and it was alarming to see the way that stuff spread. I couldn't think of anything but so many serpents crawling over the surface, gathering moisture away back on the wall. The wall was very dry, because my house is built in sandy soil. It spread over there like a fire.

I became alarmed. I wrote the Forest Products Laboratory and received a very nice letter from the director. He seemed to take as much interest in that dry rot and my trouble as if it had been his own. He described it exactly as it was and recommended what should be done under the condition. I tried one of his recommendations, which was chloride of zinc, but it had no effect on the dry rot that was already there. After thinking the matter over for a while, I took as much pleasure in ripping that closet up and burning it as I did in building it. I was afraid it would spread through all the timber of my house. I rebuilt it with cypress, treating it with a brush coating three times after it was assembled. That is as sound today as it was when I built it eight years ago.

I learned that the Forest Products Laboratory was not only equipped and interested in carrying on scientific research, but that it has an eminently human interest in the affairs of the citizens of the country, and is performing a wonderful service.

MR. F. KIMBALL (Wichita, Kan.): I would like to ask a question in regard to the white ants. There are some sixteen buildings in the city of Wichita that are being devoured by white ants at this time. In one building the casings have all had to be replaced. In another case I was called on to inspect three weeks ago the hardwood flooring was practically all eaten up. The baseboard and casings were also destroyed, and I would like to know if the gentleman has any remedy for it or suggestions to make.

MR. HUMPHREY: Gentlemen, I am afraid you need an entomologist to answer those questions. The government has done a lot of work, through the Bureau of Entomology, on white ants. There are so many ramifications of the problem that I would hesitate to discuss them before you gentlemen here. There are other men in the audience that have had similar troubles with white ants, and I would suggest that anybody who is interested in that get in touch with the office of Forest Entomology in Washington, D. C.

MR. KIMBALL (Wichita, Kan.): In regard to the creosote proposition, we have made some runs which were very adaptable to building. The run was in connection with an ordinary tunnel. We have our greatest trouble where the walls are built around the porch and filled with earth or sand and then a concrete floor run up on them. The rot gets in under the walls, goes up the sides, and gets into the joists, and the only thing we are compelling them to do is to creosote the joists in connection with those porches.

We are trying to get all the data we can. We thought you might be able to give us some data on that.

MR. H. S. SMITH (City Building Inspector, Houston, Tex.): I should like to ask if this white ant is what is known sometimes as wood lice.

MR. HUMPHREY: I am not sure about the wood lice.

MR. SMITH: I have always known it as wood lice. It is a small white insect similar to an ant. Where the joists rest on the foundation of the brickwork is the place where they begin to work and they make a road on through and keep going down.

MR. JOHN FOWLER (Building Commissioner, Jacksonville, Fla.): I would like to ask Mr. Humphrey if he can recognize this particular fungus that I am going to try to describe. We have had two cases in Jacksonville. One case was traced directly to a leak in the plumbing; the other one we never have traced. The fungus growth was of a bluish green color, and I would term it a natural velvet. It was about three-sixteenths of an inch thick. It was spread over an area about ten feet square. When my attention was brought to it, it was a question of a remedy. I went over there and bored to see whether the timber was affected. At that time the timber was not affected.

You could strip off this natural velvet, as I call it. It would hold together, and on the back of it there was a texture like velvet which was dripping water, absolutely dripping water. The only remedy I could suggest, without tearing the house to pieces, was to strip it all off. I couldn't find any leak at all. We stripped it off, took one-half of it, and brush-coated it with creosote. On the other half we used a plumber's torch. From my experience, a good way to stop a fence post from rotting is to burn it at the ground. We did the same thing with that. We took a plumber's torch and scorched it. That apparently stopped the trouble.

Three years afterwards one whole side of the tile of the bathroom fell off. That showed something was going on behind there. We went after it to find the trouble. In this particular case, the trouble was found in the shrinkage of the flooring. The plumber had made a very poor connection in the bath tub. In other words, instead of making a wipe joint he made a joint that pulled apart every time the bath tub was used and there was a small amount of water running in between the floor and the tiling. The tile was put on top of a wooden base. Ninety per cent of it is put on in that way in wooden buildings. That same stuff had gone all the way up into the plate line. Underneath it was killed. I could attribute this fungus under the house to the atmosphere, to the little amount of daylight.

Then, we had another case the cause of which we never did discover, but that was in a closed house raised up about two or three feet from the ground. There was no ventilation whatever. They tore out about all the flooring and caught it before it spread, but it was the same kind of fungus.

While I am on my feet, I want to see if Mr. Humphrey has ever noticed any close contact or any close relation between ants and so-called southern dry rot, because it has been my observation in several column failures that while they were attributable to dry rot there was every indication of ant passages, and that ants were living in the passages. That is the thought I want to bring out: whether this has been observed by your department, whether there is any close relationship between ants and dry rot.

MR. HUMPHREY: In my own experience, I have not noticed a direct connection. We have had very few samples sent to the laboratory with an attack both by the white ant and southern dry rot. According to the published literature of the Bureau of Entomology they, in a general statement, I believe, say that ants and decayed wood go hand in hand quite

frequently, so the fact that I have not observed it does not mean it does not happen. I believe it does sometimes.

Now to attempt to answer that first question, from the description you have given of the fungus, I am afraid I am up a tree. I know of no fungus which attacks any kind of timber which is of the type you describe; in other words, a bluish green and perhaps three-sixteenths of an inch thick, coming off in sheets. How did the surface of it look?

MR. FOWLER: It was like velvet.

MR. HUMPHREY: You have contributed something to science. I wish you would send me a chunk of it, although we don't need any more.

MR. KNIGHT: I have had occasion to observe considerable rot and chances for rot to develop in buildings. In regard to Mr. Woolson's proposition of floors rotting over concrete, we have observed that, but it has been conquered by using a dry cinder film. We found even then, if there was no linoleum, in mopping the floor the water would go through and rot the floor to some extent, but it can be traced to the concrete floor striking the timber and keeping it cold and damp.

In regard to joists, we have pulled the ends of joists out of brick walls and found they were in perfect condition. In the first building built after the Chicago fire, we found joists coming out in perfect shape, but we pulled many out of concrete walls that have been cast into the concrete and have rotted out in a very few years.

Another case of rot was in the Armour Company warehouse. They had got into the habit of whitewashing the joists. It was a requirement of the Board of Underwriters. It stopped ventilation and the timber and joists all rotted. The architect for Armour & Company told them about this and they discontinued the whitewashing of joists as a fire protection, because it caused rot in the wood.

There is another thing, and this is something I can't get at all. I don't know whether it is a rot or a fault in the oak timber. You run across oak that you could almost break over your knees. To all appearances, it looks like good substantial oak. We have been told that was dead timber or dead branches but we have also seen branches that stood up. It is a question whether that is a rot or what it is. I have not been able to determine. If you could enlighten me on that, I would be glad.

MR. HUMPHREY: It is pretty hard to answer questions without seeing samples, but I will attempt to generalize, and I think we can say that this particular oak that would get into the condition you mention must be rotted. There are no other agencies except perhaps chemical ones that would act on timber to rot it so you could break it over your knees. I rather expect it was rot without much physical evidence of fungus on the surface.

MR. KNIGHT: Where timber in brick walls rested on iron we have found rotting. We attributed it to the fact that it was continually kept cold and there was moisture.

MR. HUMPHREY: Many of these points can be answered only by knowing local conditions. Fungi are present everywhere, and if your timber is in the right condition to rot it is going to rot, unless we can control the moisture.

(Presented at the Eleventh Annual Meeting of the Building Officials' Conference, April, 1925, Madison, Wisconsin.)

Figure 1.--White cottony growth termed mycelium, overgrowing coniferous timber beneath the unventilated floor of a warehouse in Seattle, Wash.

Figure 2.--Extremely thin section of pine wood decayed by a heart-rotting fungus growing in a living tree, as seen under a microscope. The heavy black vertical lines are the cut walls of wood fibers; the smaller black lines running in all directions between them are fungous threads (mycelium). The small white spots are holes bored through the fibers by the fungus.

Figure 3.--Fruiting bodies of the dry rot fungus, Poria incrassata. The three upper figures show the surface with pores, inside of which are borne the spores; the two lower figures to the left represent thin sections longitudinal with the pores, showing their depth and the interior lined with spores. A few spores more highly magnified are shown at the lower right; these are dusky olive in color when mature.

Figure 4.--The posts and paired girders in this Chicago building were covered with plaster board while in a moist condition. They began to fail in approximately two years, owing to the retained moisture. The 3-inch holes were cut through the plaster board in an effort to dry the timbers after they began to fail.

Figure 5.--Some of the timbers taken from the Chicago building shown in Figure 4 were sent to the Forest Products Laboratory at Madison, Wisconsin, for strength tests. The sections illustrated were cut at approximately equal intervals from one of the girders and are arranged serially beginning with the ends. The timber lost approximately 80 per cent of its cross-bending strength.

Figure 6.--The water conducting strands (rhizomorphs) of dry rot fungi, belonging to the Merulius group much resemble cords or roots. The ones shown here are growing between the layers of lumber in a pile stored in a New England lumber yard. The growth occurred near the base of the pile and was exposed when the upper layers of stock were removed.

Figure 7.--The dry rot fungus, Poria incrassata, produces much larger water-conducting strands than does Merulius; in fact they may become as large as one's wrist and resemble roots or a grape vine stem. The timber illustrated here became infected while resting practically on the ground. The lower branched end of the rhizomorph penetrated the soil and absorbed moisture from it which it carried up into the building for nearly 25 feet, rotting the timbers as the fungus grew upward.


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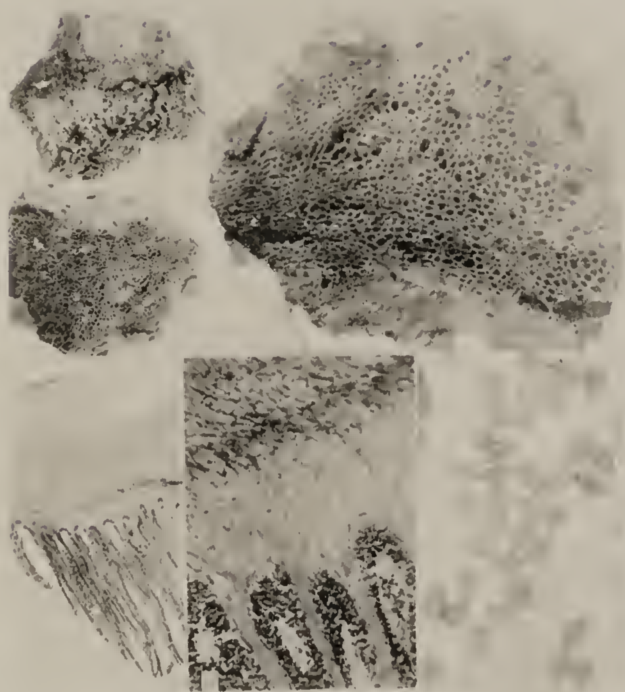
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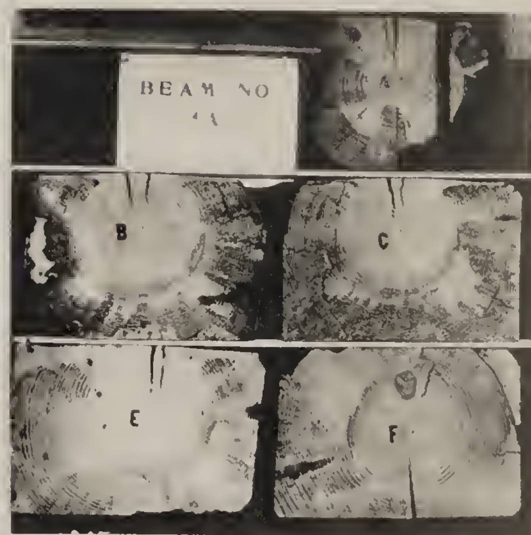

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Figure 8.--The posts under this Florida bungalow were high grade longleaf pine. The soil upon which they rest is infected with the dry rot fungus, Poria incrassata, which has entered and decayed the center of the posts leaving only a firm outer shell. The dry rot infection spread into the floor timbers and up the sheathed interior walls of the house to the ceiling, causing extensive repairs. Even complete ventilation from all sides, such as we have here, will not protect timber in contact with the ground.

Figure 9.--Floor laid on the ground in a cotton warehouse. The dry rot fungus, Poria incrassata, is fruiting abundantly on the surface. No more than two or three years life can be expected of timber used in this manner.

Figure 10.--The dry rot fungus decayed the floor in this southern Alabama bungalow and then passed up an interior wall for 6-1/2 feet. The infection entered the building by following a small strip of lumber from the ground into the wall at the point shown in the lower left corner of the picture. Negligence in leaving this strip in contact with the soil is entirely responsible for all the damage occasioned.

Figure 11.--The dry rot fungus frequently gets into lumber sheds in the South and Pacific Northwest. When the foundations and posts become infected the infection is readily transmitted in the course of a few days to sound stock. This may happen through direct contact of sound with diseased material or by means of spores which are formed on the fruit bodies and wafted about by air currents. The only remedy is thorough elimination of dry rot from the premises.

Figure 12.--Dry rot infections in stored lumber are altogether too common. They constitute a hazard to the building interests which should not be tolerated. An infected timber may soon develop into a rapid growing cancerous scourge when introduced into a building.

Figure 13.--A dry rot infection is shown at the upper edge of this floor joist just received from a southern lumber yard. Had even the crudest inspection been given this stock, such obviously decayed material would have been eliminated. If it is left in the building it may originate a dry rot outbreak involving a large area of the floor and finally spreading up the walls.

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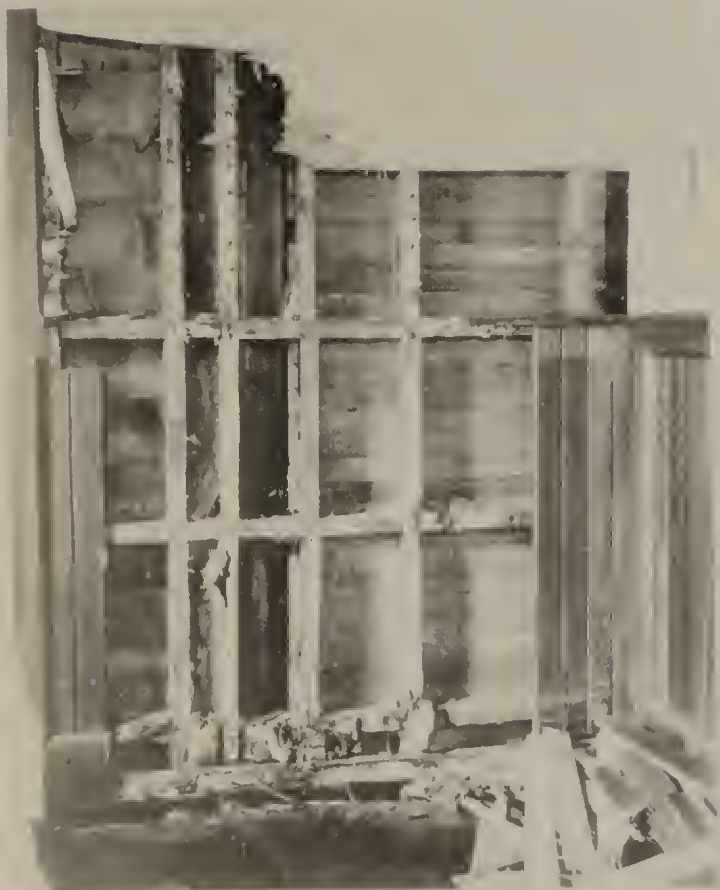

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Figure 14.--This 12 by 20-inch Douglas fir girder rotted in approximately four years in a warehouse in Portland, Oregon. The end of the timber was covered with galvanized iron and closely embedded in a concrete column. The wood was only partially seasoned when used, the moisture present, together with that absorbed from the concrete being ample for rapid decay.

Figure 15.--Many of the older southern homes are thoroughly cross-ventilated beneath and dry rot outbreaks are practically unknown in them, provided none of the foundation timbers came in contact with the soil. Modern types of construction ordinarily do not allow sufficient air circulation and sometimes no ventilation at all is provided. This encourages dry rot.

Figure 16.--Roof planks from a paper mill showing rot in a more or less middle plane. This is high grade lumber and were it not for the excessive moisture occasioned by operating conditions it would give long service. (After Hoxie.)

Figure 17.--Ends of planks in a textile mill roof rotted over the supporting beam. The rot has also extended three or four inches into the beam. (After Hoxie.)

Figure 18.--Section of roof plank and supporting beam showing the line of moisture limit at which fungous growth will stop. (After Hoxie.)

Figure 19.--Section through roof plank showing effect of a moulding in bringing the moisture line, limiting fungous growth, outside the edges of the supports, resulting in the rotting off of the ends of the planks. (After Hoxie.)

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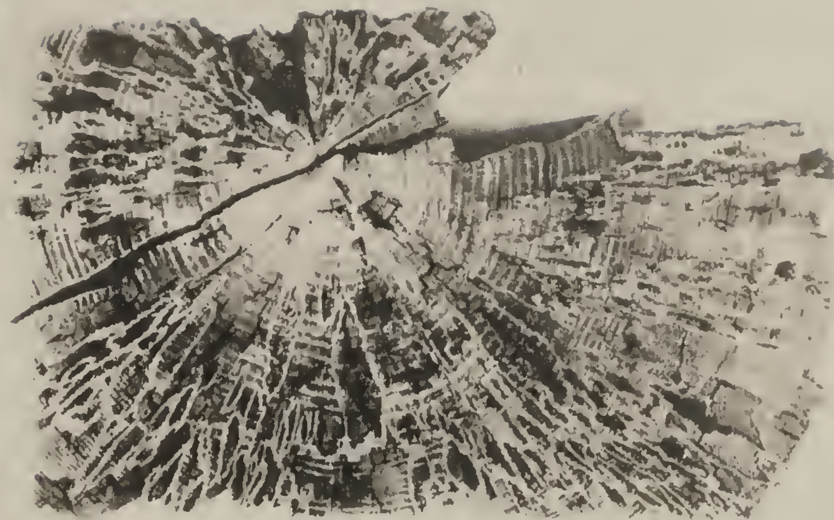

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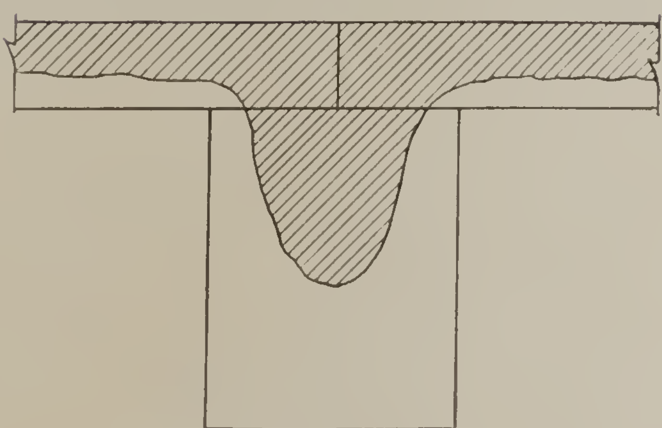

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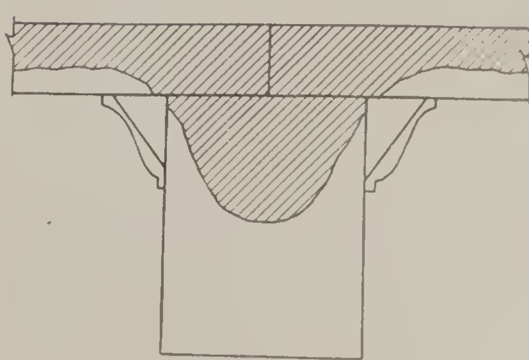

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